SECTION 7 - RECOMMENDATIONS FOR FURTHER STUDIES

The United Kingdom marine aggregate industry faces increasing difficulties in obtaining Licences for dredging in coastal waters. To a large extent these concerns are centred on two main issues:

- *what is the rate of recovery of physical and biological resources in dredged areas and in the surrounding deposits after cessation of dredging? Some reports indicate a relatively rapid recovery in mobile deposits (see*, for example*, van Moorsel 1994) whereas others show that recovery in coastal waters is incomplete even after as much as 12 years (Wright, 1977).*

- *what is the extent of the "footprint" of impact on physical and biological resources outside the boundary of the dredged area? Most predictive models based on settlement velocities estimated from Stokes' Law and Gaussian diffusion principles suggest that fine particles may remain in suspension for up to 6 tidal cycles and could therefore result in a deposition 'footprint' extending for up to 20km in each direction of the ebb and flood tides. This has led to speculation that fisheries resources, breeding grounds and the food webs upon which fish depend could be impacted some considerable distance from worked licences.*

We have shown, within this report, that there is considerable variation between the predicted model plume and that identified through field monitoring. Our observations have been observed independently elsewhere in recent projects world-wide. There is however, only a limited amount of information for U.K. waters. Site specific investigations will be important. Assessment should be made of the relative difference between impact of the largest and smaller dredgers operating in the U.K. Further, appraisal of the ecological and physical significance of the proposed and actual rates of extraction should be addressed.

It is clear that the marine aggregate industry and the Regulatory and Monitoring Authorities together need to specifically address the questions of the rate of recovery of physical and biological resources within the dredged areas following cessation of dredging, and to establish beyond reasonable doubt that the impact is confined to the immediate zone of active sedimentation close to the dredged site. As a precursor to this, 'recovery' must be defined in such a way that 'recovery' is a realistic and viable goal.

The literature review herein has indicated that the rate of recovery of areas which have not been completely defaunated is about 10x faster than in areas which have been completely defaunated. From the review of dredging operations and procedures, in particular the patchiness of the workable resource, zoning, and dredge lanes, it seems likely therefore that the rate of recovery of a commercially dredged site may be significantly faster than that reported for intensively dredged trial sites, which so far provide the only quantitative information on recovery rates for UK waters.

There is, therefore, a clear requirement for an authoritative assessment of the extent of impact and rate of recovery of resources within and adjacent to commercially dredged areas. The assessment would be required to meet the rigorous inspection and concerns of the Regulatory Authority, Fisheries Associations and Conservation Bodies who require treatment of Licence applications using the "Precautionary Approach", which to date has assumed that impact zones could be large and that full recovery of physical and biological resources is likely to be slow. Concurrently, the proposals must remain economically reasonable and technologically attainable for the dredging industry.

The techniques for establishing both the zone of impact and the recovery of resources are well established. It is feasible for the results of the necessary studies to be assembled within the next 12-18 months, which would provide key information for licence applications currently in preparation.

In Section 4.4 of this report, we have proposed approximate values which we have estimated for potential organic enrichment to the surface waters within the plume caused by the dredging operation. In Annex 1 following, the results of the work proposed and the actual measured values for organic enrichment are presented, which are in good agreement with those postulated in Section 4.4.

In Section 7.3, a number of small scale investigations are proposed that may be conducted quickly and with moderate resources to assess certain issues raised within this report. The assessment of the organic enrichment of the plume is considered a priority and should be addressed in the short term to account for the plume appearance, behaviour and impact. The techniques are readily available and can be undertaken with limited resources. It is suggested that data on the organic content is obtained during the next set of field data collection in order to confirm, or discount, this hypothesis.

All of the proposals herein are considered to be realistic goals for industry appraisal within the next two to three years, with some results potentially available within 8-10 months. The information will allow scientific fact to replace poorly informed speculation and unwarranted allegations of permanent damage to the seabed and benthic environment. Knowledge of such information will enable competent and authoritative monitoring programmes to be emplaced and workable mitigation measures to be developed. Unnecessary sterilisation of useable resources may justly be avoided.

7.1 Rate Of Recovery Within Dredged Area & Surrounding Deposits

As mentioned previously within this report, there have been few detailed studies on the impact of dredging on biological communities on the seabed in the United Kingdom, or on their subsequent rate of recovery following cessation of dredging. The most frequently cited work is for an intensively dredged experimental site off the UK Norfolk Coast (Kenny & Rees, 1994; 1996), from which it was concluded that recovery was substantial but remained incomplete even 2 years after cessation of dredging in the experimental area.

As noted previously, it must be remembered the experimentally dredged area mentioned above differs significantly from most commercially dredged areas. Our comprehensive review indicates that there is no information, similar to the studies by Kenny *et al*, available to confirm the extent to which commercially dredged areas conform to the results of experimentally dredged areas.

Evidence of the potential for significant variation of recovery rates due largely to the intensity of dredging operations is suggested, for example, by the results of investigations of shell dredging activities off Tampa Bay, Florida, which reported up to 10 years required for recovery of benthic communities following complete defaunation, whereas recovery from incomplete defaunation was completed within 6-12 months (*see* Benefield, 1976; Conner & Simon, 1979).

Studies such as these provide clear evidence that areas of physically undisturbed deposits between the furrows may provide an important stock of colonising species that are available for rapid lateral migration over the limited distances to the freshly disturbed seabed within the furrows (*see also* Section 6).

It follows that where complete defaunation does occur, migration distances for colonisers are much greater, posing predator threats etc., and consequently resulting in the longer recovery times (*see also* van Moorsel, 1993, 1994).

7.1.1 Field Study Proposal One

A study of the physical impact of dredging within a commercially dredged area and its surrounding deposits should be combined with a qualitative study of the biological resources to establish the following;

(i) the impact within a commercially dredged area compared with surrounding undisturbed sites

(ii) the progression of recovery of physical and biological resources within the areas where dredging has been completed

It is anticipated that a commercially dredged licence area will show a more rapid recovery than experimentally dredged areas, and that seabed topography is likely to be restored rapidly in the relatively shallow coastal deposits of the UK aggregate industry (*c.f.* evidence from many overseas investigations largely conducted in deeper, less disturbed waters) (Newell *et al*, 1998).

It is suggested that a region of past intensive and extensive dredging activity containing a number of Licences, exploited over a considerable number of years would provide a suitable assessment for this proposal. The history of phased dredging, conceded areas and zoning undertaken on the ‘Norfolk Banks’ provides a range of examples of presently, recently and long-since worked areas, with ‘refuge’ zones between them.

Considerable information is available within the “Norfolk Banks” area in the form of geological prospecting reports and Environmental Statements containing some benthic investigations data. The results of Kenny & Rees (1996) would be geographically similar for comparison of commercially dredged and experimentally dredged results.

7.2 The Extent Of Dredging Activity "Footprint"

The concern that the modelled and observed behaviour of a dredging plume is significantly different requires further investigation. It is known (see, *for example*, Gajewski and Uscinowicz, 1993; Whiteside *et al* 1995; Hitchcock & Dearnaley, 1995; Land *et al*, 1996; reviewed in Newell *et al*, 1998) that the settling velocities of the plume observed in the field do not conform to established settling velocities of similar sized (discrete) particles determined through laboratory tests. This is considered due to a combination of factors including initial entry velocity of the mixture into the water column, cohesion of the fine particles to the coarser particles (which are separated during laboratory particle size analysis) and the formation of density currents (*see* Chapters 2 & 4).

The potential for a major zone of impact stretching as much as 20km along the tidal current flow in each direction is therefore remote. Importantly, very recent research (J. Rees *pers. comm.* 1997) has observed passage of a 'plume' within the benthic boundary layer (approximately less than 1m from the seabed) at distances of up to 8km from the dredging activity. Suspended solids concentrations are not known, but are likely to be of the order 80-100mg/l. It is possible therefore that where seabed roughness and induced turbulence exists, the excursion of a small, fine component of the plume may be extended.

There has not, however, been any investigation of the actual field impact of dredging on biological and physical resources within and immediately adjacent to commercial dredging activity.

Determination of the actual settlement pattern of the plume has had limited address (*see* Gajewski & Uscinowicz, 1993). Deployment of settlement traps / devices to determine real deposition rates away from the dredge zone will support and refine all previous plume investigations and modelling, and relate directly with benthos studies.

Analysis of tracer sediments is unfortunately limited to defining the settlement pattern of the tracers (which are, by definition, required to and are marketed to mimic the behaviour of the discrete particles within the sediment), rather than the behaviour of the dredged sediments interacting not only with each other but also with the biological and chemical conditions prevalent. Further the vigorous agitation of the dredging process is as yet an unknown process.

The determination of "*Contours of Impact*", a procedure well documented for point sources of environmental disturbance and stress, could be determined authoritatively for dredging activities. A detailed study of the changes in sediment granulometry and seabed topography across the dredged area and corresponding relationships with biological resources has been submitted for funding, under an extension of the present contract with the MMS. This is anticipated to commence in October 1998 through to September 2000 with early results available during late 1999.

7.2.1 Field Study Proposal Two

During extensive resource prospecting and reserve evaluation surveys carried out during 1997, we have obtained non-quantitative evidence that the zone of impact on biological resources is indeed small and confined to the immediate vicinity of the dredged area (Newell & Hitchcock, *memo to* ARC Marine, August 1997).

We therefore recommend that an integrated physical and biological monitoring survey is carried out on an existing, licensed aggregate extraction area to authoritatively establish the zone of impact surrounding the dredged area. It is considered important to gather information on the actual sedimentation pattern of the dredged sediment overboard returns, unaltered by treatment or tagging. We therefore strongly suggest development of a robust and simple technique for deployment of purpose built sediment traps suitable for midwater and seabed deployment. The recently raised issue (J Rees *pers. comm.*) of a "benthic boundary layer" plume extension (*circa* less than 1m high) needs to be addressed and could be considered concurrently. The utility of sediment trap data is reinforced, for example, by Drapeau *et al* (1992) and Gajewski & Uscinowicz (1993).

This would provide indisputable field evidence that the zone of impact, which to date potentially extends as far as the plume has been modelled using the "Precautionary Principle", is actually much more confined, and falls well within the zone of plume excursion as identified through recent field monitoring. Such an exercise may also temper some of the (growing) perceived 'cumulative effects' of neighbouring Licences.

It is anticipated that the biological response zone to the plume will actually not extend as far as the limits of the observed plume, considering the capacity of the benthos to cope with natural variations in suspended solids concentrations, sediment stability and sediment accretion rates.

By this means, correlating an observed plume impact zone with an observed biological impact zone will provide, for the first time, unequivocal evidence of the relationships between benthos and plumes and an assessment of the levels of enhanced suspended solids concentrations which can be ascribed to particular benthic responses, whether negative or positive.

7.3 Aesthetic Plume Impacts, Far Field Effects And Perception

The aesthetic impact of the far field plume raises the potential criticism that since the surface expression is extensive, therefore the plume must be detrimental to the environment. A significant cause of concern, and which subsequently arouses a perception of negative impacts of plumes, may be resolved by investigation of the content of the visual far field plume; be it biological, physico-chemical or geological. The sediment plume is a very visual phenomenon; explanation of the visual component will probably satisfy more objections than many other perceived and identified physical impacts.

7.3.1 Field Study Proposal Three

It is proposed that further monitoring of the water column plume is undertaken using a combination of water sampling (with testing for geological, biological and physico-chemical components), VMADCP™, Optical Backscatter and Transmissometer Sensors, and Aerial Photogrammetry.

As outlined in Section 4.4, it is proposed that, to a large extent, the far field plume visible by the unaided eye and recorded by Continuous Backscatter Profiling has significant biological origins. It is proposed that during the next phase of fieldwork undertaken either from a dredger or from a separate survey vessel, water and plankton samples are obtained to assess the quantity of biomass in suspension within the overflow and reject sources. It is considered that this need not in the first instance be a high cost exercise: a limited sampling campaign will ascertain the presence, or otherwise, of elevated organic levels.

Further, it is considered necessary for the biological parameters distinguishing positive, negative and no effects to be determined. Some data may already exist, and it is only necessary therefore to competently apply such data to the UK marine aggregate mining plume.

Preliminary discussions with Aerial Photogrammetry companies have concluded that given known ground markers (navigational buoys, marker buoys *etc*.) and their known locations, scaled and quite accurate dimensions of the visual plume extent can be made. These can be correlated with concurrent observations by ADCP™ and sample test results to explain the character of the far field plume.